SCALE

GRID STABILITY AND MARKET DISRUPTION – A POLICY ANALYSIS FROM THE PERSPECTIVE OF BI-DIRECTIONAL CHARGING

Deliverable 5.3

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1.1 1.1 Legal Disclaimer

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2 Project Executive Summary

SCALE (Smart Charging Alignment for Europe) is a three-year Horizon Europe project that aims at preparing EU cities for mass deployment of electric vehicles and the accompanying smart charging infrastructure.

3 SCALE Partners

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- Eindhoven (NL)
- Toulouse (FR)
- Greater Munich Area (GER)
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4 Deliverable Executive Summary

This deliverable falls under SCALE work package five “Preparing for mass deployment & legal recommendations and standardisations”, and more specifically under Task 5.3 “Legal, market & regulatory framework to enable mass-deployment.”

This deliverable is a legal analysis of the policy landscape relevant to bi-directional charging in the EU. The current version is the final version of the deliverable.

As a conclusion of the analysis, the recommendation is not to promote more regulation, rather to explore and establish a first praxis in relation to the regulations coming into force. The praxis will inherently be context-dependent as access to the grid, the balance between supply and demand of electricity, the size of relevant vehicle fleets and the price of electricity vary across the EU. One size does not necessarily fit all. In order to establish praxis, the Net-Zero Industry Act and the related public procurement of net-zero technologies, regulatory sandboxes and net-zero valleys can play an important role in initiating an EU-wide transition into scalable and resilient energy solutions that incorporate bi-directional charging.

4.1 Key Words

Policy, AI Act, Data Act, Net-Zero Industry Act, Batteries Regulation, Regulatory Sandboxes, Digital Decade, Green Deal, New Legislative Framework

4.2 Document Aim

The aim of the document is to inform relevant stakeholders of the legal opportunities and requirements regarding mass-deployment of bi-directional charging within the EU.

The report is written as a stand-alone product. This is not to say that it represents all the work done by partners contributing within work package five (WP5) when it comes to legal, market and regulatory frameworks to enable mass-deployment. The report is a deliverable where we focus on the possible long-term effects of the legal landscape to clarify the business opportunities this brings in order to facilitate private and public investments that steer towards a competitive and resilient charging infrastructure within the EU.

5 Purpose of the Deliverable = Reference to Select the Content

5.1 Attainment of the Objectives and Explanation of Deviations

Task 5.3 has investigated and evaluated policy options within the EU. The initial application sought "a response to the outdated and fragmented legal, market and regulatory framework, to prepare updating laws or writing new ones". Since the time of application the policy landscape has changed rapidly, one could claim that policy development has outpaced technology innovation lately. The focus has therefore shifted from proposing new laws to understanding the impact of the latest policy development within the EU. Here the emphasis has been on the business opportunities of bi-directional charging, rather than the policies pushing for fossil-free alternatives within the transportation sector. We believe more in the carrot than the stick, so to say.

The deliverable still addresses issues such as data availability (see the discussion on the Data Act and the Batteries Regulation), technical requirements (as in product safety described in the sections on the AI Act and the Batteries Regulation) and market structures (see the section on emerging themes), with the ambition to guide to realistic introduction of bi-directional charging. Different perspectives have been obtained through three workshops organised by the SCALE consortium were the ambition and the analysis have been laid out according to the progress of the analysis.

As a conclusion of the analysis the recommendation is not to promote more regulation, rather to explore and establish a first praxis in relation to the regulations coming into force. The praxis will inherently be context-dependent as access to the grid, the balance between supply and demand of electricity, the size of relevant vehicle fleets and the price of electricity vary across the EU. One size does not necessarily fit all. In order to establish praxis, the Net-Zero Industry Act and the related public procurement of net-zero technologies, regulatory sandboxes and net-zero valleys can play an important role in initiating an EU-wide transition into scalable and resilient energy solutions that incorporate bi-directional charging.

5.2 Structure of the Deliverable and Links with other Work Packages/Deliverables

This deliverable is structured as follows:

- Motivation and Scope: Describes the chosen regulations and the overall methodology behind the analysis.
- The EU Policy Landscape: A brief introduction to the EU product safety framework, the Digital Decade and the Green Deal.
- The Digital Decade and Bi-Directional Charging: A high-level introduction to the technical requirements and the access to data in the light of the AI and Data Acts.
- The Green Deal and Bi-Directional Charging: Product safety and data access for batteries, according to the Batteries Regulation, as well as new measures to facilitate innovation and procurement of net-zero technologies, the Net-Zero Industry Act.
- Emerging Themes: Regulatory sandboxes shall promote innovation of novel technologies as well as regulatory compliance, the dual leadership in terms of regulating bi-directional charging in a European context, the implications of enabling consumer products to control critical infrastructure as well as the impact of new data strategies and energy flows on the opportunities for monetization.

- Future Work: Further exploration of the four themes is needed. This could be complemented with viewing bi-directional charging in the perspective of societal resilience and the need for adequate cyber-security recommendations.
- Conclusions and Recommendation: In relation to the original SCALE ambitions, there is no need for more regulation. Rather first praxis on how to implement those regulations coming into force as we speak. The emerging praxis should be anchored in a geographical context as access to grid codes, supply and demand of energy, data maturity etc. are context-dependent.

The following work packages, WPs, have deliverables immediately connected to this report:

- WP2 describes the technical contributions and relevant documentation.
- WP3 describes the implementation of the pilots and the contextual factors taken into consideration.
- WP5 describes the return of investment calculations and the procurement program.

6 Motivation and Scope

While we know there are numerous regulations that relate to bi-directional charging, this report does not focus on those that motivate actors to complement or replace fossil-driven vehicles. Rather, we position bi-directional charging in the changing European policy landscape with an emphasis on policies that will impact future business models and value propositions. In our research we use the term policy, not as in politics or lobbying, but as in rules and their implementation in a broader sense (hence encompassing regulations, directives, standards, company guidelines etc). We have chosen the following policies as the foundation of our analysis:

- The AI Act,
- The Data Act,
- The Batteries Regulation, and
- The Net-Zero Industry Act.

The analysis is research in progress and not legal advice. It is also important to recognize that all of these legal acts are stepwise applicable from 2024 into 2027.

First, a word on why we have focused on these four policies. We have deliberately chosen what we see as most relevant in relation to establishing long-term, viable business models. This is grounded in the ambition of the SCALE-project[1], where the charging infrastructure can accommodate what is sometimes called vehicle-to-grid, or bi-directional charging. Our analysis covers CE-marking of AI-systems related to bi-directional charging and takes into account a previous analysis of the AI Act and the Data Act regarding[2] In a second step the analysis was extended by adding regulations from the Green Deal, with batteries seeming an obvious connection since battery data is interlinked with costs and business models, was in the initial analysis and batteries are a core component of bi-directional charging. The issue of data

[1] The ambition of the SCALE-project is to explore a vehicle-to-grid setting. However, our policy analysis of bi-directional charging is not limited to vehicles but could cover stationary energy storage and other solutions enabling bi-directional charging.
[2] H. Burden, S. Stenberg and M. Olsson, Proposed EU Regulations Impact on Data Utilisation – A Multi-Case Study within Public Transport, 2023, https://www.diva-portal.org/smash/get/diva2:1752571/FULLTEXT01.pdf.

availability was also stressed in the given task. That was then complemented with Net Zero Industry Act since it introduces the concept of regulatory sandboxes, just as the AI Act does.

The following analysis represents our way of working in trying to make sense of how multiple regulations interact in relation to new technology or business opportunities. Our approach is to start small, iterating incrementally, rather than doing everything at the same time and seeking a complete analysis. This approach includes keeping a dialogue with relevant stakeholders throughout the process, importantly allowing adaptation and reflection[3].

Other regulations are also interesting but out of scope for this deliverable (due to time and resources). For example, digital product passports have a connection to the Data Act and the Batteries Regulation, platform regulations such as the Digital Service Act and Digital Market Act in relation to large platform owners with an interest in the automotive industry, the Energy Efficiency Directive for reducing energy consumption and so on. Though we determined that these were out of scope for this analysis they may well be worth looking into, and we will come back to this in the section on possible new research trajectories under Future work.

7 The EU Policy Landscape

Both the Green Deal and the Digital Decade can be traced back to Ursula van der Leyen's speech to the European Parliament in 2019.[4] In that speech she laid out the need for climate action as it "will help us cut emissions while creating jobs" while also stating "that there is no future without digitalisation". And, as we shall see, these two initiatives are grounded in the framework governing the internal market.

7.1 The Digital Decade and the Green Deal

The Digital Decade is the EU's strategy for digitalization and encompasses both new regulations[5] and concrete targets[6]. Both the AI and Data acts emanate from the Digital Decade.

The Green Deal is the overall strategy for ensuring that the EU reaches climate neutrality. It comes with specific targets[7] as well as several regulations for different sectors communicated as the "Fit for 55" legislation[8]. The Batteries Regulation and the Net-Zero Industry Act are part of the Green Deal package.

[3] H. Burden and S. Stenberg, Agile Approaches to Policy Development, XP 2022 Conference, Copenhagen, Denmark, https://www.agilealliance.org/wp-content/uploads/2022/06/Tomas-Gustavsson-BurdenStenberg-XP2022.pdf.
[4] Speech by President-elect von der Leyen in the European Parliament Plenary on the occasion of the presentation of her College of Commissioners and their programme, 27th November 2019, https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_19_6408
[5] European Commission, Report on the state of the Digital Decade, 2nd July 2024, https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_24_3602/IP_24_3602_EN.pdf
[6] DECISION (EU) 2022/2481 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 December 2022, establishing the Digital Decade Policy Programme 2030, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32022D2481
[7] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality (European Climate Law), OJ L 243, 9.7.2021, p. 1–17, http://data.europa.eu/eli/reg/2021/1119/oj
[8] European Commission, "Commission welcomes completion of key 'Fit for 55' legislation, putting EU on track to exceed 2030 targets", https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4754

Taken together, the Green Deal and the Digital Decade forms the basis for EU's twin transition towards a resilient economy[9].

7.2 The New Legislative Framework

The EU has adopted a set of policies that are designed for facilitating the free movement of goods across the EU, focusing on product safety. This approach is known as the New Legislative Framework (NLF). The regulatory foundation can be found in three policies[10] which together provide for:

- Market surveillance: how product safety and compliance is governed on an EU and Member State level,
- The CE-mark: general and sector-specific requirements for product safety,
- Conformity assessment bodies: neutral, third parties that assess compliance before products are placed on the market, and
- Accreditation: the process of ensuring the neutrality and competence of the conformity assessment bodies.

The NLF includes a wide variety of sector-specific products, ranging from machinery, personal protective equipment and toys to medical devices, fertilizers and pyrotechnics. The policies posing the general and sector-specific requirements are often complemented by harmonized standards that further detail and explain how the legal requirements are to be met.

8 The Digital Decade and Bi-Directional Charging

In relation to the Digital Decade, we have chosen two regulations for further exploration – the AI Act[11] and the Data Act[12]. Both are extensive regulations in terms of scope and pages, and we have deliberately focused on what we judge most relevant to bi-directional charging. Those interested in more details on stakeholder roles and responsibilities, fines for non-compliance, accreditation of notified bodies, standards etc. will have to look elsewhere.

8.1 The AI Act – Safety of AI in Critical Infrastructure

The AI Act defines an AI system as "a machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual

[9] European Commission, Towards a green, digital and resilient economy: our European Growth Model, 2nd March 2022, https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_22_1467/IP_22_1467_EN.pdf

[10] Regulation (EC) 765/2008 setting out the requirements for accreditation and the market surveillance of products, Decision 768/2008 on a common framework for the marketing of products, which includes reference provisions to incorporate in product legislation revisions. In effect, it is a template for future product harmonisation legislation, and Regulation (EU) 2019/1020 on market surveillance and compliance of products.

[11] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) OJ L, 2024/1689, 12.7.2024, http://data.europa.eu/eli/reg/2024/1689/oj

[12] Regulation (EU) 2023/2854 of the European Parliament and of the Council of 13 December 2023 on harmonised rules on fair access to and use of data (Data Act), OJ L, 2023/2854, 22.12.2023, http://data.europa.eu/eli/reg/2023/2854/oj

environments". The EU Commission has proposed guidelines on how to interpret and implement the definition.[13]

This report will not dig deeper into the definition or the specific systems it will affect but rather keep it high-level. In the context of implementing a technology solution that entails bi-directional charging an essential finding to keep in mind, however, is the following:

IF a system fits within the AI Act's definition of an AI system,
AND the AI system is used as a safety component within either of two specific domains:
1 – products such as machinery and radio equipment[14,15]
2 – road traffic management, electricity supply and digital infrastructure[16]
THEN the AI system shall be CE-marked before put on the market or taken into use.

As mentioned above the AI Act is stepwise applicable. This means that for the first domain regarding machinery, radio equipment etc. the act is applicable from 2nd August 2026. For the second domain, regarding critical infrastructure, the act is applicable from 2nd August 2027.[17]

It is worth pointing out, in relation to bi-directional charging, that the first set of products (1) does not cover vehicles and vehicle equipment[18]. Our assessment is that the division of products relates to the UN's mandate to regulate vehicles from a multi-lateral perspective while machinery can be regulated on a national basis. And for most European countries that national mandate has been transferred to the EU-level through the Treaty of the Functioning of the EU.[19]

In summary, our analysis shows that the AI Act will require that some actors comply with new technical and organizational requirements in order to get their products and services on to the EU market. That cost should be taken into consideration when formulating a business model encouraging actors across the value chain to be involved in bi-directional charging.

8.2 The Data Act – Rights and Obligations for Disrupting Value Chains

The Data Act defines data as "any digital representation of acts, facts or information and any compilation of such acts, facts or information, including in the form of sound, visual or audio-visual recording". According to the Data Act, data generated from using connected products should be seen as a digital representation of the user (someone who owns, rents or leases the product). Therefore, the user has the right to such data free of charge, without delay and in an established (ie standardized), machine-readable format. According to the Data Act, data generated

[13] EUROPEAN COMMISSION, ANNEX to the Communication to the Commission – Approval of the content of the draft Communication from the Commission – Commission Guidelines on the definition of an artificial intelligence system established by Regulation (EU) 2024/1689 (AI Act), C(2025) 924 final, Brussels, 6.2.2025
[14] The complete list is found in Annex I(A) of the AI Act and can be broadly seen as regarding product safety as regulated under the NLF: https://eur-lex.europa.eu/eli/reg/2024/1689/oj/eng#anx_I
[15] See e.g. H. Burden, S, Stenberg and K. Flink, "When AI meets machinery – the role of the notified body", 2024, https://www.diva-portal.org/smash/get/diva2:1903512/FULLTEXT01.pdf
[16] The complete list is found in Annex III of the AI Act and can be seen as regarding AI in relation to fundamental rights and health.
[17] Article 113 of the AI Act gives the full details of when the act becomes applicable: https://eur-lex.europa.eu/eli/reg/2024/1689/oj/eng#art_113.
[18] The complete list of products out of scope can be found in Annex I(B) of the AI Act: https://eur-lex.europa.eu/eli/reg/2024/1689/oj/eng#anx_I
[19] Consolidated version of the Treaty on the Functioning of the European Union, http://data.europa.eu/eli/treaty/tfeu_2016/oj

by using a vehicle, and thereby its components (such as a battery), is an example of data emanating from a connected product.[20]

The kinds of data that are covered by the user's rights include relevant meta-data (such as when the product is in standby mode) and data representing usage or prestanda of the product. But also diagnostic, raw or prepared data. However, analysis or information derived from the data is out of scope. The application of know-how to the data and the resulting analysis is seen as something different than the data itself and there should be a commercially viable market for deriving the know-how and the ways to apply it.

A user can request that the data holder shares the data with a third party for a standardized reimbursement: i.e. the user is not restricted to the know-how and application provided by the data holder but is free to seek out other offerings if they better fit their needs. This opens up for a third party as a service provider. But it also enables data holders to be service providers for other products than their own. An important caveat is that data cannot be used to analyze the product as such (by competitors).

The Data Act is deliberately disruptive, seeking to change the ways data is used for digital services. The ambition is both to facilitate maintenance and circular / 2nd life business models for connected products, but also to free data from the current silos imposed by contractual agreements under unbalanced bargaining positions. The regulation is stepwise applicable, so that e.g. the rights of the user come into force on the 12th September 2026 and the rules regarding unfair contractual arrangements are applicable for agreements made after 12th September 2025 (or for old contracts after 12th September 2027 if they do not expire before 11th January 2034).[21]

In short, the data flow will change! And that means that monetization of data will also change. From our horizon, this needs to be accounted for in developing suitable business opportunities around bi-directional charging. Data flow is one of three critical flows we address further down.

9 The Green Deal and Bi-Directional Charging

From the Green Deal we have chosen the Batteries Regulation[22] and the Net Zero Industry Act[23]. Just as in the case of the AI and Data acts, the chosen regulations are substantial and cover multiple topics such as product safety, public investments and governance at both EU and Member State level. We have deliberately chosen what we see as most relevant in relation to establishing long-term, viable business models and recommend the reader to explore the full impact of the regulations.

9.1 The Batteries Regulation – CE-marking energy storage

Above we referred to the NLF and the notion of product safety, the Batteries Regulation introduces CE-marking of energy storage based on technical documentation. This means that

[20] See recital 14 of the Data Act, which states that connected products are found for instance in vehicles. See footnote 1 for an analysis regarding battery data.
[21] The full list of when the different articles become applicable can be found in article 50 of the act: https://eur-lex.europa.eu/eli/reg/2023/2854/oj/eng#art_50
[22] Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries, OJ L 191, 28.7.2023, p. 1–117, http://data.europa.eu/eli/reg/2023/1542/oj.
[23] Regulation (EU) 2024/1735 of the European Parliament and of the Council of 13 June 2024 on establishing a framework of measures for strengthening Europe's net-zero technology manufacturing ecosystem, OJ L, 2024/1735, 28.6.2024, http://data.europa.eu/eli/reg/2024/1735/oj.

some batteries need to be CE-marked, but batteries covered by the UNECE type approval for vehicles are exempt.

The regulation also introduces battery passports containing "information relating to the battery model and information specific to the individual battery, including resulting from the use of that battery". This resonates nicely with the Data Act and the rights of the user to obtain data on usage, battery cell capacity and so on. Such data can then be used to assess the next phase in the battery life cycle:

- reuse (the battery is to be reused without other preprocessing),
- repurposing (e.g. transferring the vehicle battery into a stationary energy storage),
- remanufacturing (e.g. substitute parts of the battery for other parts), or
- recycling materials (which parts of the battery are to be recycled as what).

The Batteries Regulation has been generally applicable since 18th February 2024, but some obligations related to the waste management of batteries are not applicable until 18th August 2025.[24]

9.2 The Net-Zero Industry Act – Technologies Enabling EU Climate Targets

The Net-Zero Industry Act acknowledges that a strong manufacturing base is needed to manage the green transition. The Act is applicable from 29th June 2024, with some exceptions[25]. It therefore sets out to clarify public procurement of (applicable from 30th June 2026) and other interventions related to net-zero technologies (applicable from 30th December 2025). It should also be easier to get permits for establishing net-zero technologies in general and dedicated net-zero valleys for facilitating synergies between net-zero initiatives. This also includes establishing academies and developing learning credentials connected to net-zero industries and supporting a workforce for quality jobs.

The act specifies several net-zero technologies, of which some are clearly relevant for bi-directional charging:

- Battery and energy storage
- The electricity grid, including charging technologies
- Energy efficiency solutions
- Plants for renewable energy

Our analysis hence implies a stream of public funding investing in these technologies and the supporting infrastructure and the needed know-how. This public funding can flow through direct means, such as subsidies supporting organization when investing in clean technology products, or through indirect means like procurement rules. The act, for example, opens up for implementing mandatory non-price criteria like reduced emissions and resilience to be used in public sector procurement procedures. Both sustainability and resilience can be seen as qualitative factors in the bi-directional charging context.

[24] The full details are given in article 96 of the regulation: https://eur-lex.europa.eu/eli/reg/2023/1542/oj/eng#art_96
[25] See article 49 of the act for the full set of details: https://eur-lex.europa.eu/eli/reg/2024/1735/oj/eng#art_49

10 Emerging Themes

In this section we will discuss four themes that cut across the analyzed regulations and give different perspectives on how to move forward. The four themes are:

- Regulatory sandboxes, as introduced both through the Digital Decade and the Green Deal regulations,
- The aspect of international governance of technologies enabling bi-directional charging,
- The implications of having consumer products controlling critical infrastructure, and
- The impact on monetization as the flows of data and electricity change.

The themes are not orthogonal but rather a way of discussing the implications of the four regulations under consideration.

10.1 EU Regulatory Sandboxes

Both the AI Act and the Net-Zero Industry Act introduce the concept of regulatory sandboxes. And, just to be clear, the concept can be found in other regulations at the same time as it is used in contexts broadly related to innovation and research. We think it is necessary to make a distinction between using the concept in general and the legally defined intervention supporting innovation. So, unless otherwise stated, when we use the term regulatory sandbox, we will refer to AI regulatory sandboxes and Net-zero regulatory sandboxes as defined in the two acts.

Since the legal details are found in two acts regulating different technologies, it is not surprising that there are both similarities and differences between an AI regulatory sandbox and a Net-zero regulatory sandbox.

In terms of similarities, they are both governed by a designated authority to facilitate innovation and foster regulatory compliance. It is worth stressing that a regulatory sandbox does not open up for exemptions in the application of law, the participants are still liable for any material harm caused and the authorities shall still exercise their supervisory powers.

The objective of Net-Zero Regulatory Sandboxes should be “removing barriers, alleviating regulatory burden, reducing regulatory uncertainty, and supporting innovation in net-zero technologies or other innovative technologies”. The AI Regulatory Sandboxes should improve legal certainty, foster innovation and the development of an AI ecosystem, contribute to evidence-based regulatory learning, as well as facilitate and accelerate access to market.

An in-depth analysis of the concept of regulatory sandboxes shows the AI and the Net-Zero Regulatory Sandboxes focus on regulatory clarity. They also have common themes in supporting innovation of net-zero technologies, as the AI Act opens up for using personal data for another purpose than it was originally collected for, if the AI system can facilitate “green transition measures”, “safety and resilience of transport systems and mobility, critical infrastructure and networks” and/or “energy sustainability”. The GDPR still applies, however operating in the regulatory sandbox enables processing of data for the purpose of training, testing and validating of AI-systems intended to facilitate the transitions mentioned above into more sustainable energy and mobility solutions.

The balance between facilitating innovation, the integrity of the individual and the need for environmental protection is hereby made more explicit when implementing AI-services and clean technology.

Thus, the legal concept of regulatory sandbox can be used to explore topics related to bi-directional charging, such as:

- AI-based safety components for the grid,
- AI for energy efficiency, and
- AI-based cyber-security for critical infrastructure.

A regulatory sandbox could also be combined with the concept of valleys for technologies enabling bi-directional charging, allowing for synergies in the exploration of how to implement and govern bi-directional charging as a net-zero technology. The regulatory sandbox is a way to collaborate on how to implement new services, hence establishing a praxis. This can then be openly and freely shared also with actors outside of the regulatory sandbox, enhancing clear market conditions to all actors.

10.2 International Governance of Technologies Enabling Bi-Directional Charging

We see from our analysis how the EU is actively regulating the space left by the UN. This is prominent in:

- How the AI Act regulates AI-based safety components in machinery but not UNECE's type approval of vehicles,
- How the Batteries Regulation introduces CE-marking of energy storage, except for vehicle batteries, and
- How the Data Act covers a wider scope of connected products, including vehicles, which is possible for there is a lack of UNECE-regulation on the rights regarding vehicle data.

The relationship between the UNECE and the EU in terms of regulating product safety is important as certain products can fall under different schemes depending on their (intended) usage. Since usage can change over time, it is important to recognize that the compliance with one schema might not be sufficient for the new purpose. That raises the aspect of not only assessing if a new compliance procedure is to be applied for the new purpose, but also to design, document and produce products so that it becomes straight-forward to re-assess products as they enter new life-cycles. The latter now being a perspective encoded into EU regulation, as e.g. seen in the Data Act and the Batteries Regulation.

Taking batteries as a concrete example, it means that they can become more expensive to put on the market but also that new business opportunities arise over time for the same battery or its sub-parts. Accommodating such costs and future possibilities will be important for finding viable business models.

10.3 Three Flows of Changing Energy

Bi-directional charging will mean a new flow of electricity, from the vehicle's battery to the grid. That change of flow will not happen in isolation as the flow of data between actors also will change. Taken together, the flows will affect the possibilities regarding monetization of bi-directional charging, which means a new flow of money.

A possible outcome of bi-directional charging is that the costs for taking care of spent batteries will increase as the lifetime expectancy decreases when the batteries are used in a way they were not designed for. That in turn can lead to new business opportunities as we know more about individual batteries and thereby possible next life-cycles. Or it could lead to new designs regarding vehicle batteries that in turn might, or might not, support both the growing business in

reuse and bi-directional charging. Here the change in flow of data regarding batteries will play an important role.

The Data Act will not only standardize revenue streams for data transactions, but it will also allow for new data transactions. And while the data transactions are regulated, the information services developed based on the data transaction can have a price model based on a supply-demand logic. Navigating these dual trends will have an impact on the viability of individual actors' revenue flows.

As more vehicle owners engage in bi-directional charging there is also a possibility that the net gain will decrease when massive numbers of actors behave the same way at the same time. That raises the question of whether there will be a market for green shaving for the end user? Most probably the answer will depend on regional and local differences across the EU in terms of overall demand and supply. A business model that works in the Netherlands might not be viable in northern Sweden or rural Spain - aspects such as differences in electricity prices and willingness to use an EV differ and thereby affect the supply and demand of bi-directional charging.

The variations across pricing will not only depend on a supply-demand logic as both the energy and data markets are regulated. Standard reimbursement for data transactions and different price zones will mean that some revenue streams are more fixed than others.

In short, the trick is to get markets with a reward, not only for one organization or industry but for all actors involved in the chain that realizes bi-directional charging. Accomplishing that can vary across regions and communities and accordingly requires context-dependent policy instruments.

10.4 Consumer Products Controlling Critical Infrastructure

Bi-directional charging of electric vehicles imposes at least two axes that need calibrating at the same time if the technology is to deliver on its promise.

The first axis regards the distinction between product safety of consumer products that are available “off-the-shelf" on the one hand, and the product safety of critical infrastructure, safeguarded under national and EU interests, on the other hand. Creating micro-markets that are open for bids from local actors within the boundaries set by the DSOs (distribution system operators) is one way to move forward and enables the DSO to adapt context-specific guardrails as the supply and demand for bi-directional charging will depend on the supply of suitable vehicles and demand for electricity. We will most probably not see the same conditions in the north of Sweden as in the south of the Netherlands.

The second axis balances the ambition to facilitate rapid transitions towards net-zero technologies enabling a green transition within the EU, with the ambition of free trade and avoiding tariffs that hamper exports and imports. There is a strong ambition from the EU Commission to facilitate investments in European initiatives for net-zero technologies through public procurement, which we’ve showed includes bi-directional charging. That could be seen as unjust subsidies by other actors on the global market for energy and vehicles. At the time of writing, we have the statement from President van der Leyen regarding European sovereignty that “In a nutshell, over the last 20 to 25 years, our business model has basically relied on cheap labour from China, presumably cheap energy from Russia, and partially outsourced security and security investments. These days

are gone. And we see that today Europe continues to lag behind the United States and China in productivity growth. And we must fix our weaknesses to regain competitiveness".[26]

These statements are made in the context of wider global shifts, represented, for example, by President Trump's memorandum on Reciprocal Trade and Tariffs, stating that his administration will formulate a plan mitigating "any unfair limitation on market access or any structural impediment to fair competition with the market economy of the United States [that] shall ensure comprehensive fairness and balance across the international trading system by factoring in losses as a result of measures that disadvantage the United States as applied, regardless of what they are called or whether they are written or unwritten."[27]

Finding the right intersection of the two axes will be important if bi-directional charging technologies are to gain sufficient market shares to support viable business models.

11 Future Work

The analysis can be further enhanced to cover policies regarding cyber-security[28] and the Gigabit Infrastructure Act[29], among many introduced through the Digital Decade program. Another topic we consider investigating is the possibility of using the legal concept of regulatory sandboxes to explore AI in relation to grid safety and bi-directional charging. The regulatory aspects in terms of how to interpret the requirements on AI-based safety components for critical infrastructure in relation to grid efficiency and stability can thus be complemented by further exploring the impact on monetization of the flow of data and energy, with the aim to establish conditions for commercially viable business models. A third trajectory is the exploration of net-zero industry acceleration valleys in relation to bi-directional charging, creating strong, co-located clusters of initiatives that deliver the needed technology as well as opportunities for quality jobs.

12 Conclusions and Recommendation

The policy analysis is not comprehensive in terms of listing all regulations that can influence actors to invest and engage in the shift towards bi-directional charging, rather it tries to pin-point some of the ongoing EU initiatives that will have a direct effect on the pricing of the enabling technologies and the economic transactions emanating from vehicle-to-grid supply of electricity:

1. The AI Act and the implications for investments in grid stability and product safety,
2. The Data Act that explicitly aims to disrupt the data market,
3. The Batteries Regulation with implications for second life and re-purposing of vehicle batteries, and

[26] European Commission, Statement by President von der Leyen on the EU Competitiveness Compass, Brussels, 29th January 2025, https://europa.eu/newsroom/ecpc-failover/pdf/statement-25-364_en.pdf
[27] The White House, Reciprocal Trade and Tariffs, 13th February 2025, https://www.whitehouse.gov/articles/2025/02/reciprocal-trade-and-tariffs/

[28] Regulation (EU) 2024/2847 of the European Parliament and of the Council of 23 October 2024 on horizontal cybersecurity requirements for products with digital elements (Cyber Resilience Act), OJ L, 2024/2847, 20.11.2024, http://data.europa.eu/eli/reg/2024/2847/oj

[29] Regulation (EU) 2024/1309 of the European Parliament and of the Council of 29 April 2024 on measures to reduce the cost of deploying gigabit electronic communications networks,
Gigabit Infrastructure Act, OJ L, 2024/1309, 8.5.2024, http://data.europa.eu/eli/reg/2024/1309/oj

4. The Net-Zero Industry Act that opens up for public procurement of relevant technologies.

We have found four regulations that will both pose new opportunities for monetization but also require investments if the promises are to be realized. Finding a reasonable division of responsibilities and rewards is crucial if the chain of actors is to commit to a shift that is more than just reversing the flow of electricity.

In relation to the four policies, we have also found four themes for further exploration:

1. The role of the AI and Net-Zero regulatory sandboxes in facilitating innovation,
2. The importance of navigating EU and UN product safety regulation,
3. The impact on monetization of changing flows of electricity in combination with new data transactions, and
4. The merging or conflict as imposing axioms are to be aligned for large-scale adoption of bi-directional charging.

In relation to the original ambitions of the SCALE-project, to overcome an “outdated and fragmented legal” framework by proposing new laws, our main finding is that the need is to establish first praxis in relation to those regulations coming into force as we speak. The policy landscape includes no union laws prohibiting the technologies of bi-directional charging and there are several policy enablers (in the form of union legislation) to incentivize new businesses. It seems, the technical development is outpaced by policy development. The emerging praxis should be anchored in a geographical context as access to grid codes, supply and demand of energy, data maturity and so forth are context dependent.